A sectorial approach to international environmental agreements

The case of the maritime sector

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Summary

Despite overwhelming scientific consensus on the importance of reducing greenhouse gas emissions, it has proven very difficult to create a comprehensive international environmental agreement targeted at limiting these emissions. Sectorial agreements have been proposed as a means of bypassing many of the more difficult parts of negotiating an economy-wide agreement.

Despite being a hot topic in the environmental debate, the subject of sectorial agreements is under-studied within the field of economics. My contribution to this topic will be a survey of the existing literature on international environmental and sectorial agreements, where I define six essential criteria that any successful environmental agreement should meet. I later apply these criteria to the maritime sector, where several propositions for a sectorial agreement are currently discussed within the International Maritime Organization (IMO).

My main conclusions from this qualitative study of sectorial agreements are firstly that sectorial agreements can ensure that a higher percentage of emissions from the sector are included. There are several reasons for this. Asymmetry between countries is reduced when only looking at one sector, and they thus have more common ground. If fewer countries are large producers of the good in question, fewer participants are needed. Additionally, costs are more certain, eliminating uncertainty that could make countries less inclined to sign. Secondly, it is easier to impose credible threats when the scope is limited because gains from participation can be clearly stated. Trade restrictions can be imposed on goods from non-signatories. Thirdly, a tax is the more efficient instrument to reduce CO_2 in general because it is a stock pollutant, and in sectorial agreements in particular because price stability is more important than the yearly quantity of emissions. And lastly, in the case of the maritime sector, a combination of taxes and command-and-control instruments should be employed. A tax because it is the most efficient instrument. Command-and-control instruments because maritime sector is a carbon-intensive sector with high abatement costs and long-lived investments. If carbon-intensive ships are built now because the tax is lower than the marginal abatement cost, the sector will be “locked” to a more emission-heavy path, making abatement costs even higher in the future.

1 Introduction

An all-encompassing international environmental agreement (IEA) has become something like the holy grail of environmental economics. Some believe it a myth; others desperately seek to find it. The idea that all emissions and pollution, regardless of source, could be integrated and regulated within one framework could be the single most effective weapon in the race against climate change. If one were to succeed in pricing greenhouse gasses, to be sold at a market like any other commodity, the market could figure out the rest itself. While the idea is alluring, it has been proven to be quite difficult to realize. The often criticized Kyoto Protocol is the most ambitious effort to date, but it has failed as a global agreement.

One of the possible ways forward sketched in the Bali Action Plan is sectorial agreements. This is not a new idea. Already in the Kyoto Protocol international aviation and marine bunker fuels were omitted with the intention of making sectorial agreements. The main purpose of this thesis is to survey the literature on sectorial agreements, assess their potential benefits, and apply it to the case of the maritime sector. In order to do that, I will measure the agreements' success against six criteria: cost-effectiveness, participation, compliance, environmental effectiveness, carbon leakage and competitiveness.

There are many criteria and variables I could have included. Technological innovation and distributional concern are two of them. They are both important issues, and I will touch upon them several times. The reason for not treating them individually is that they are important mainly because of the way that they influence one or more of the chosen criteria. Technological innovation is important because it affect cost- and environmental effectiveness. Distributional concerns are largely important because they influence participation. The six criteria chosen also affect each other, but they each constitute such important features of an international agreement that they deserve individual treatment. Through them, I believe that most other variables can be discussed.

I will use some terms interchangeably. I will sometimes write IEA, sometimes simply agreements and sometimes treaties or protocols. Not all agreements are treaties, but all treaties are agreements. My main focus throughout the thesis will ultimately be emission of greenhouse

gases, but I will sometimes talk solely of CO_2 emissions. CO_2 is the most important greenhouse gas, and is a good proxy for greenhouse gas emissions as a whole. I will also sometimes refer to the maritime sector as just the shipping sector, without there being any qualitative difference between the two.

The thesis is structured as follows: In the second section I go through the theory of IEAs and elaborate on the six above mentioned criteria that I believe are essential for it to be successful. In the third section I discuss the theory of sectorial agreements, or lack thereof. I also outline the properties of suitable sectors and assess whether a sectorial agreement in general can fulfill the six criteria. In the fourth section I go through the properties of three possible instruments for emission abatement, command-and-control instruments, taxes and tradable permits. In the fifth section the evidence found in the previous three sections is applied to the case of maritime sector. The last section concludes with the main findings and some final remarks.

2 The theory of international environmental agreements

IEAs have even only recently been much discussed in economics, despite the large number and scope of these agreements. As late as in 2003, when the first issue of the comprehensive Handbook of Environmental Economics was published, the issue was altogether ignored. Only later it became a field of interest, but the literature is growing rapidly.

As the literature grows, the number of definitions grows with it. In political science IEA's are often defined like this: "an international environmental agreement is an intergovernmental document intended as legally binding with a primary stated purpose of preventing or managing human impacts on natural resources" (Mitchell 2003). This is in line with the understanding of the 1969 Vienna Convention on the Laws of Treaties' definition of a treaty. An agreement is thus international even if it is not signed by some minimum percentage of the world's states or even if it is not international in its scope. The term international environmental agreement is common in economics as well, but seldom precisely defined.

Emissions of greenhouse gasses are in its nature a global issue. The air does not take notice of national borders and the consequences are unevenly spread. For an agreement to truly address this issue, it would have to be *global*, not just international in the literal sense of the word. An IEA in general need not have more than three signatories to be labelled as such, but an agreement on emission of greenhouse gases would not be addressing the issue if not a sufficiently large part of the world's emitters were signatories.

Mitchell's definition excludes non-governmental parties. The definition also excludes non-governmental parties. In IEAs as in sectorial agreements, both international organizations and NGO's are important players. They are an important source of information and facilitator of agreements, and are invaluable as such. They are also often given the role as supervisory bodies after the agreement is in force, and have the power to make important regulations and resolutions that do not need the explicit consent of the member states at the highest level. The organization around agreements is vital to the success or fail of an agreement (Mitchell 2003). The dynamics between an agreement and its institution are important, but outside the scope of this thesis. I will therefore confine myself by pointing out the importance of a good institution that can administer the purpose of the agreement in the future, and not just its letter.

2.1 Past experiences

The first multilateral, if not international, environmental agreement can arguably be said to be the Agreement between Austria, Baden, Bavaria, Switzerland and Württemberg respecting the Regulation of the Flow of Water from Lake Constance, signed at Constance, 27/31 August 1857 (Mitchell 2015). The agreement, signed by all the then-nations bordering Lake Constance, states that no nation is allowed to build any dam or dike near the entrance to the river Rhine because of the damage caused by high water levels to all surrounding areas. Several treaties concerning Lake Constance followed throughout the second half of the nineteenth century, regulating in large parts navigation and fishing. And though they all target small issues, together they constitute a framework covering all kinds of conduct on Lake Constance.

While the issues dealt with in these agreements differ considerably in scope and complexity from the issues the world is facing today, they were all made to regulate a public good. Lake Constance was, and is, a vital source for drinking water, fish and recreation for all the surrounding nations. Through periods of political turmoil between these states, they managed to agree on certain rules on this separate and specific issue. The treaties are still in force and institutionalized in the Internationale Gewasserschutz-Kommission für den Bodensee. This is one of these strong institutions created to follow up treaties. Through these institutions the original treaties are continually interpreted and translated into policies and their structure may be a crucial factor to the treaty's success or failure.

The Montreal Protocol on Substances that Deplete the Ozone Layer is often cited as the most (or the only) effective agreement on limiting emission of an air pollutant. It is a protocol to the Vienna Convention for the Protection of the Ozone Layer and aimed to phase out the use of chlorofluorocarbons (CFCs), a greenhouse gas that depletes the ozone layer. While the primary objective of the Montreal Protocol was to stop the depletion of the ozone layer, it has also proven highly effective at reducing emissions of greenhouse gases that are indirectly targeted in the protocol. According to Velders, Andersen et al. (2007), the Montreal Protocol has been much more efficient at reducing greenhouse-gas emissions than the Kyoto Protocol by design could ever be.

The Montreal Protocol was successful because it managed to include a record-high number of participants, it compensated developing countries for the cost of compliance without exempting them from the responsibility, it targeted both the use of CFCs in production *and* in consumption of emission-intensive goods, and it included a credible threat of punishment for non-compliance. All this resulted in a powerful incentive for technological improvements (Barrett 2008). Although the Montreal Protocol often is used as an example of a successful treaty, it is important to keep in mind that agreement addressed a very specific problem. It is easier to ban a production input when there already exists alternatives, than it is to lower emissions from a production input that is not replaceable in the short run. The nature of the problem with carbon emissions is very different from that of CFC.

Consistent with economic theory, the Kyoto Protocol aimed at creating a common framework for different kinds of greenhouse gases, ensuring that cuts and improvements would be made where

it was most effective. By bundling all the gases into one system, the marginal cost of abatement would be equal across the board. This is a textbook cost efficient way of lowering emissions, a first best solution to a public goods problem. Low-hanging fruit would be picked first, and it would incentivize technological improvements where it would have the greatest effect. The initial agreement would be followed by several subsequent agreements, each solidifying the framework and deepening the scope.

The problem encountered in Kyoto is not as much the idea as its implementation. The Montreal Protocol was limited to one gas and its content was more forceful. The Kyoto framework did not include a credible threat of punishment to either countries that chose not to ratify or countries that did not meet their obligations. It did not even demand reductions of most of the countries. Only the so-called Annex I countries were obliged to limit their emissions, and only for a five-year period. 20 years later only a very few countries, like the UK and Australia, have managed to hit their target, but more because of luck than a high degree of effort. Others, most notably Canada and New Zealand, have massively increased their emissions in the same period. Clearly, the Kyoto Protocol has not succeeded in changing the behavior of the signatories very much (Barrett and McIlveen 2009).

2.2 Criteria for success

I will use six criteria for deciding whether a climate change agreement is efficient or not. It must be cost effective, have broad participation, incentives for compliance, reduce emissions substantially, limit carbon leakage and it must address competitiveness concerns. Though these criteria are closely related, I will address each of them separately in the following.

2.2.1 Cost-effectiveness

An agreement is said to be cost-efficient if it can reach an abatement target at the lowest cost possible. The least-cost theorem of pollution control says that the marginal cost of abatement must be equal across all firms. This does not imply that abatement costs will be equal in absolute

terms, but rather that the abatement will be undertaken at firms that have the lowest marginal abatement costs.

In a pre-IEA setting one could imagine that the cost of emission is zero. If the IEA, by some instrument to be described in a later section, manage to increase the cost of emissions, then all firms who have smaller abatement costs than emission costs will choose abatement. Thus only the cheapest abatement measures will be implemented.

Cost-effectiveness is an important feature of any agreement. No-one would argue that it is better to use more resources than necessary to reach a certain goal, but many will disagree in how cost-effectiveness is measured. In a modelling framework it is easy to see whether a particular instrument will be cost-effective or not, but in the less-than-perfect setting of the real world, it might not be as easy. Administrative costs and other transaction costs might make an otherwise cost-efficient instrument more expensive than the alternative.

The Kyoto Protocol was hailed by many for its cost-effective approach; it managed to make a comprehensive framework where abatement of several greenhouse gas emissions was tradable. The different greenhouse gases were weighted according to severity, but the idea was that it did not matter whether it was sulfur or carbon emissions, marginal abatement costs would be equal for all emitting firms. One of the critiques of the Kyoto Protocol has been that the idea of cost-effectiveness came at the expense of environmental effectiveness. By trying to include all, the Protocol did not manage to reduce any of them sufficiently.

2.2.2 Participation

As mentioned earlier, climate change is global in nature. An effective agreement thus has to have broad participation, both in its number of signatories and in the percentage of total emissions covered. If the agreement is not ratified by all states, it gives the non-signatories a comparative advantage. Where the signatories have to lower their emissions either through costly investments in green technology or by buying permits, the non-signatories does not have to incur these extra costs. According to standard trade theory, the non-signatories will increase their production of emission-intensive goods because the relative price of production has gone down. So while the

signatories lower their emissions, that effect might be outweighed by increased emissions elsewhere.

If the agreement is not ratified by some of the larger emitters of greenhouse gases this will not only give those countries a comparative advantage, it might undermine the whole system. The symbolic effect of the US and China refraining to ratify the Kyoto protocol has been damaging to the willingness to contribute by other states as well as lowering the overall effect (den Elzen and de Moor 2002).

Barrett (1997) comes to the rather pessimistic but strong result that when the difference between the cooperative and the non-cooperative is large, i.e. when the agreement actually changes the behavior of the signatories, it will only be able to sustain a very low number of signatories. An IEA could only sustain a large number of signatories if the difference in outcomes was very small. This result tells us that we are only likely to get an IEA with broad participation if the agreement in reality only describes what each signatory would do unilaterally in any case.

2.2.3 Compliance

It does not matter much if the agreement is unanimously agreed upon if the countries do not comply with it. Models of IEAs usually assume rational behavior and complete information. That implies that no country would sign an agreement with the intention of shirking. Though it might make sense in a one-shot game theory framework, as soon as it is expanded to a repetitive game, this strategy would of course lead to less or no abatement the second round (Barrett 2005).

Even if this strategy is not rational from a theoretical viewpoint, it is far too easy to find empirical evidence of states not fulfilling their obligations. Canada's target under the Kyoto Protocol was a 6% reduction in greenhouse gas emissions from a 1990-level by 2012. By 2008 the emissions had increased by 24% and in 2011 the country withdrew from the treaty (UNFCCC 2011).

In order for countries to comply, an agreement must include credible an effective punishments for non-compliance. For the punishment to be effective, the cost of the punishment must be bigger than the gain of deviating. But even severe punishments are worth little if the threat is not

credible. Punishments often hurt the imposer as well as the receiver. If these costs are too large, the threat is not credible. In some cases the costs of carrying out punishments could even outweigh the entire gain from participation, and the country would choose to abstain from the agreement altogether (Carraro and Siniscalco 1998).

Different schemes have been proposed to include credible threats to an IEA. An often used punishment for non-compliance is simply exclusion. With trade agreements or other economic agreements, this is effective because it exist clearly defined economic benefits from being a member. As clean air is a global public good, exclusion from the agreement is not a credible threat.

Stiglitz (2006) among others proposes an enforcement mechanism somewhat similar to the one planned for the Montreal Protocol: either prohibit trade of energy-intensive goods with non-signatories or impose tariffs large enough to compensate for the advantage gained by not complying. This is a threat quite similar to the ones which are effective in trade agreements like the WTO. The issue is however a bit different from the Montreal Protocol, because it is much easier to impose tariffs on CFC-produced goods. Those goods were easily identified and substituted. To identify products and reduce the use of CO_2 and other greenhouse gases would be much more difficult. The tariffs would also hurt trade partners and could be used to target goods that are unwanted for political or other reasons.

Another proposal is to include some sort of club good in the agreement. Either something directly related to climate change, e.g. technological cooperation, or by linking climate change to another, excludable, benefit like development cooperation (Carraro and Siniscalco 1998). Whether or not these threats would be credible depends on the nature of the club good as well as the costs of carrying out the punishment.

2.2.4 Environmental effectiveness

A fourth criterion for an efficient agreement is whether it actually addresses the issue or not. An agreement with broad participation, credible threats of non-compliance and cost-effective instruments is worth little if it does increase abatement from a non-cooperative alternative.

Environmental effectiveness is a measure of how much impact the agreement has on the environment compared to a business as usual scenario.

Environmental effectiveness can be increased in two ways. The first is by making stringent abatement targets. The existence of an agreement must force the signatories to abate more than they each would do unilaterally. This can be achieved by linking different issues, thus countries would agree to give more on one issue if they got something in return. Summarizing over all countries, the combined abatement should be higher than the no-agreement alternative. Alternatively transfers could be made to reluctant countries, to compensate for high abatement targets.

I mentioned the critique of the Kyoto Protocol earlier; by trying to include all greenhouse gas emissions; it did not reach an agreement on sufficiently strong reductions. A study by den Elzen and de Moor (2002) of the economic effectiveness of the Kyoto Protocol concludes nonetheless that the single largest impact on environmental effectiveness was the US withdrawal from the permit market. That fact illustrates the second way in which environmental effectiveness can be increased (or decreased, as in this case): broad participation. The argument is easy; the more signatories or the larger share of emissions that are included, the more efficient the treaty.

2.2.5 Carbon leakage

If one group of countries enters into an agreement and imposes a restriction on the use of greenhouse gases in production, the Heckscher-Ohlin theorem predicts that the production of greenhouse gas-intensive goods will increase in countries outside the agreement. This is because greenhouse gas emissions will be relatively cheaper in these countries, and they will gain a comparative advantage in production of those goods. This holds especially true for emission-intensive trade-exposed sectors.

Any IEA without full participation will to some degree or another have to address this problem. The fewer participants an IEA has, the greater the carbon leakage. Manne and Amano (1994) estimates that if the OECD countries were to reduce their greenhouse gas emissions by 20%, the carbon leakage would be as high as 30%, leaving the effective abatement level at 14%. For the

abatement among Annex I countries the estimates of carbon leakage varies from 5% to 20% (Perman, Ma et al. 2011).

2.2.6 Competitiveness

Competitiveness between firms, or ensuring a level playing field, is usually not considered directly when modelling IEAs, unless it leads to carbon leakage. Politically however, this is an important issue. National pressure and special interest groups are often opponents of environmental requirements because it makes them less competitive. If the same requirements were enforced everywhere this distortion would no longer be an issue and it might be more politically edible.

It is however important to keep in mind that abatement policies are meant to make environmentally friendly firms and sectors more competitive. Not all competitiveness issues can or should be avoided, so some firms will evidently face larger costs. Short- and medium-term costs of policies are likely to be outweighed by long-term economic, social and environmental benefits (OECD 2009). This criterion is therefore foremost meant as an indicator on domestic opposition.

3 The sectorial approach

The idea that a sectorial approach to climate change issues could be fruitful is not new. The possibility of using sectorial agreements on aviation and marine bunker fuels was even introduced by the UNFCC in 1997. But while the enthusiasm for a comprehensive agreement might have cooled somewhat since 1997, the sectorial approach seems to gain supporters (e.g. Bradley, Baumert et al. (2007), Meckling and Chung (2009), Bodansky (2007)). The proponents of this approach emphasize that while an all-encompassing international agreement clearly is a first-best policy in a perfect competition economy, the reality is that we live in a second-best world. First-best policies are perhaps not achievable or they may have unwanted effects.

One of the problems encountered when researching sectorial agreements is the lack of previous theoretical research. While there is no shortage of economic models of IEAs and multiple regional agreements and their characteristics, very little has been done to make a formal theoretical framework for studying sectorial agreements. In fact, there is not even a clear consensus on a definition. Usage varies from describing voluntarily agreements between companies of clearly defined and homogenous activities like cement production to more diverse and loosely defined categories like land use or transport. From the fact that the agreements are tailored to one specific issue, it follows that it is difficult to make general observations.

Equally important as the size and qualities of the sector, is at which institutional level the agreements are made. I will discuss the properties of agreements made at an intergovernmental level, either with negotiations directly between states or within a governmental organization like the UN. The agreement must be limited to a defined industry or use of resource, aimed at reducing emissions at this area in particular.

3.1 Suitable sectors and models of frameworks

The literature does not propose that sectorial agreements should in any way replace or substitute the current work with a comprehensive agreement. Rather, it is argued, it can be a supplement on areas where some kind of emission reduction scheme is urgent, where there are significant potential for reduction or where it is difficult for states to regulate. How strong ties it should have to a larger framework is however debatable.

3.1.1 Determining suitable candidates

Not all sectors are suitable candidates for sectorial agreements. Several studies (e.g. Stephenson (2009) and Bradley, Baumert et al. (2007)) have tried to list a set of criteria that can determine whether a sector is suitable for a sectorial approach or not. I will use the five criteria explained below. They are not exhaustive or unambiguous, but serve as a good framework for discussion of the agreements' economic merit.

First of all, one should look at the share of global greenhouse gas emissions and the rate at which the emissions grow. The share of emissions can tell us something about the scope, while the growth rate is a better determinant of urgency and severity in the future. While there is no perfect percentage for a sector to be a candidate for sectorial agreements, there has to exist a problem in order to fix it. Also, the problem should be large enough to justify the extra resources used on making a separate agreement.

The second criterion is that there must be a significant potential for emission reduction. Again, the gain from carving out an agreement must be worth the time and resources used. Knowing the potential reduction can also help prioritizing one sector over another. A high-carbon sector that requires quite modest adjustments in order to reduce their carbon footprint is a better candidate than a low-carbon sector where the future prospects of abatement are small or very expensive relative to output.

Thirdly, sectors with a large concentration of actors or owners are more likely to be good candidates. With few and easily identified actors it is possibly easier to reach an agreement, and the problem of leakage is smaller if all major actors agree. It is also reasonable to expect that a concentration of owners will make it easier to estimate overall costs and benefits, thus increasing the certainty of outcome (Bodansky 2007).

The fourth criterion is a high level of trade, or international exposure. This is not because there is some inherent quality of domestic sectors that disqualify them from sectorial agreements, but rather because international sectors demand different solutions. Sectorial agreements can have the advantage of better addressing concerns about competitiveness and carbon leakage, which is among the most important issues for international sectors. If these concerns are addressed it can ensure broader participation. It also prevents that governments, committed to an economy-wide target, shield certain important sectors from abatement requirements to better their competitiveness. Sectors that are exposed to international competition are likely to be more willing to make concessions and commit if those concerns are lessened (Bodansky 2007). For some highly international sectors it is also difficult to determine to which states the emissions should be allocated. This is certainly the case for international aviation and shipping.

Finally, a sectorial agreement might be more effectual where there is a high degree of homogeneity of production. This is because such sectors can cooperate on more areas, be it technological standards or R&D. It is also easier to set a benchmark for emission if the production is somewhat similar in all firms. Again, the costs of abatement would be more certain to all if the production were similar. The production of steel and aluminum are examples of highly homogenous productions.

There is no easy way to quantify these criteria, but all can be assessed and measured qualitatively.

3.1.2 Models of sectorial agreements

Bradley, Baumert et al. (2007) have outlined five different models of sectorial agreements. The first is the sector-only model, where one only has multiple sectorial agreements and no comprehensive framework. While it could be envisaged that these agreements could be linked in some way, the extra burden of negotiating a new, separate agreement for each sector makes this alternative unlikely.

The second alternative is an addition model, where a sectorial agreement supplements a comprehensive agreement and engages only additional countries. This could be an alternative where one aims at expanding the comprehensive agreement by easing additional countries into the framework. This model will most likely not suit sectors in international competition. Firms would be subject to two different agreements depending on the nationality and would thus have to address problems of carbon leakage and loss of competitiveness.

The third model is the complementary model. In this alternative, countries may be subject to both agreements. The complementary agreement would deepen the obligation of large emitters in certain sectors, without requiring that all also are members of the comprehensive agreement. This alternative takes into account that it is unlikely that large emitting countries like China, India or USA will join a comprehensive framework in the near future, and thus allows for cooperation on chosen sectors instead. This alternative is better suited for international sectors, given that both agreements are negotiated simultaneously. It retains the intention of making an economy-wide IEA, but allows for the fact that not all countries are willing to cooperate on all

areas. The danger here is of course that all countries will choose to keep some domestically important sectors out of the main agreement, and only make commitments for parts of the economy. This undermines both the environmental and cost effectiveness of the agreement.

The fourth model is the carve-out model. Here we envisage a comprehensive agreement where certain problematic or special sectors are left out, with the purpose of being included in a separate agreement. This was the approach chosen in the Kyoto Protocol when it chose to exclude bunker fuel emissions from aviation and marine traffic. The idea is that some sectors have inherently different characteristics and are international in its nature, and are thus better handled on a global level, rather than treated it as domestic emissions.

The final alternative is the integration model. The sector in question would be part of a comprehensive framework, but subject to certain specified rules or procedures. This has the benefit of involving only one agreement, and hence enables tradeoffs in bargaining and cost-efficiency. This approach would be suitable when the aim of the agreement is not a new policy, but rather to expand or deepen the policy in certain sectors.

Most of these models are not substitutes, but dependent on the sector(s) in question. The carve-out model is the model most fitting for sectors that themselves do not fit in an economy-wide agreement. The other models are more or less modifications to the idea of an IEA that is incomplete for pure political reasons. When looking at the maritime sector in section 5, the carve-out model will be the obvious choice.

3.2 Criteria for success

So given that a suitable sector is found, and that a fitting model of agreement framework is used - can a sectorial agreement achieve something that an IEA cannot? Going back to the criteria for a successful IEA from section 2.3, can sectorial agreements mitigate some of the problems of the IEA?

3.2.1 Cost-effectiveness

On an economy-wide scale, sectorial agreements are not cost-effective. The least cost theorem of pollution control says that the price on greenhouse gas emissions must be equal across both sectors and gases. When it is, all firms who have smaller marginal abatement costs than the marginal emission cost will implement abatement measures, regardless of industry and gas. This is cost-effective because only the firms with lowest abatement costs will abate.

In a sectorial approach, this will not hold true across sectors. Aggregate abatement costs will be higher, because the lowest marginal abatement cost in one sector might be higher than that of another sector, leading to an efficiency loss if the firm with higher abatement costs is forced to abate because they are part of a more stringent agreement.

One could however, argue that a sectorial agreement would be cost-effective within a sector. Perhaps even more so than an IEA, if we assume that more actors will sign a sectorial agreement than a comprehensive IEA. The loss of global cost-effectiveness must be weighed against sectorial cost-effectiveness and in some cases the gain of even having an agreement.

3.2.2 Participation

One of the main criticisms of the Kyoto Protocol is that it failed to include large emitters like the USA and that only the Annex I countries had to commit to emission reduction targets. While it was hoped that this would be a first step leading the other countries to join later, this seems very unlikely now (Stephenson 2009). The difficulty of finding good solutions between very heterogeneous and asymmetric countries has been apparent.

Sectorial agreements might not have the same problem. As the chosen sector should have concentrated ownership or a homogenous product, it is likely that the necessary number of participants is lower. In the case in international shipping, land-locked countries would automatically not be important, and the to five top countries own 53% of world tonnage (UNCTAD 2013). When the number of possible participants is low, it is easier to find common ground (Bodansky 2007).

Additionally, the scope of the negotiations would be smaller. This has both positive and negative consequences. On the upside, this means that otherwise diverse countries can be regarded as more homogenous. There will be differences in installed technology and size of the industry, but these will be small relative to what you get if you compare two whole economies. This can potentially make the negotiations easier. There is a lot of common ground, and not as much need for special deals and exceptions. This will both increase participation and strengthen the agreement.

On the downside, the fact that the scope of the negotiation is smaller might lead to very specific and technologically difficult negotiations (Bradley, Baumert et al. 2007). There would be some information asymmetry between government negotiators and sector representatives, and it could open up domestic sector issues. If the sector in question is an important and powerful political entity in participating countries, they might require special treatment or have specific claims (Philibert 2005). It might also be politically difficult to single out one sector that has to take a larger share of the burden, depending on what model of sectorial agreements that is chosen.

But because the agreement would be quite technical and sector specific, this can also alleviate some uncertainty issues. When the scope is smaller, there is possibly more certainty with respect to costs and benefits. The cost analysis can be based on technological bottom-up analysis and the sector can with greater certainty forecast the costs. This might make the argument more convincing to national interest and pressure groups (Philibert 2005), and thus make the agreement more politically feasible domestically.

Although there are both positive and negative sides to sectorial agreements when it comes to participation, most agree that it is likely to gain broader participation than full-scale IEAs (e.g. Sawa (2008), Bodansky (2007)).

3.2.3 Compliance

The difficulty of making credible threats is one of the big problems when designing an IEA. The very specific threats mentioned (but not even used) in the Montreal Protocol are difficult to replicate on an economy-wide scale. This is easier if the agreement only apply to one sector. It is simpler to exclude a non-signatory when the emissions are a result of a specific production. To

prohibit trade or impose tariffs on non-signatories could more easily be implemented. The products made by non-signatories could easily be identified and, if the goods are sufficiently homogenous, substituted with goods produced by signatories. The same logic can be applied to services – only companies that comply with the agreement can operate in countries that have signed the agreement.

Club goods could also more readily be used. The disadvantage of being excluded from technological cooperation or R&D could have larger consequences for a single sector than an entire economy. At the same time, the gains from deviating might be smaller because the obligations are smaller.

The cost of punishing non-signatories would probably also be smaller, making the threat more credible. Excluding one country's production of a single good is a much more manageable and sure cost than trying to harm an entire economy. The risk of retaliation remains, but the severity of this threat would depend largely on how powerful the non-signatory is.

This is one of the main advantages of the sectorial agreement. By specifying the requirements, the consequences can also be specified. Trade restrictions are already very successfully used as a punishment for non-compliance in the Montreal Protocol, the WTO and other trade agreements. By using sectorial regulations to limit greenhouse gas emissions in certain international sectors the problem can be transformed from one of a uniformly mixed pollutant that know no boundaries, to one of a question as to whether a good can be sold internationally or not. The latter problem is one that is much easier solved, one that in fact has been solved many times over.

3.2.4 Environmental effectiveness

The fact that sectorial agreements are unlikely to be cost-effective can hurt the environmental effectiveness. Compared to an economy-wide IEA, agreements covering only specific sectors will not be as effective, thus resulting in lower abatement. Looking at inter-sectorial competition, it might reduce the effectiveness further. Stricter regulations imposed on a low-carbon sector might better the competitiveness of a more carbon-intensive sector, thus actually incentivizing investments in the high-carbon products (Sawa 2008).

When working only with one sector, regulators loose the opportunity to link different issues. There is less room for maneuvering and compromises, thus perhaps leaving the agreement less extensive and binding than it could have been if several issues were on the table. This reduces the overall environmental effectiveness.

In the long run, all mitigation efforts are highly dependent on technological improvements. While it is often assumed that carbon prices will promote technological development, no significant evidence has been found proving this relationship (Sawa 2008). With sectorial agreements that raise revenue through a permits auction or a tax, it is possible to specify targeted R&D efforts that are shared between the participants.

3.2.5 Carbon leakage

Where IEAs have the problem of carbon leakage to non-signatories, sectorial agreements (assuming larger participation) have the problem of carbon leakage between domestic sectors. Capital is more mobile within a country than it is globally. This is partly a result of investors' home bias, where domestic investors prefer to invest in domestic firms rather than foreign. This result suggests that there will be domestic carbon leakage if one sector is singled out for regulations. However, simulations have nonetheless found this effect to be small, but increasing with the number of non-regulated sectors (Stephenson and Upton 2009). This result is an argument for only using sectorial agreements as complements, rather than a main strategy.

Also, the elasticity of substitution between goods within one sector can reasonably be assumed to be much greater than the elasticity of substitution between goods produced in different sectors. It is easier to substitute a car with another car than with a boat. That implies that the carbon leakage between different sectors is smaller than the carbon leakage between different countries, but within the same sector. The disadvantage of not including the whole economy could be partly alleviated by reduced carbon leakage.

3.2.6 Competitiveness

Many countries have already imposed unilateral climate mitigation regulation, often to fulfil some obligation the country has committed to through an international agreement. These regulations can differ greatly between signatories and especially between signatories and non-

signatories. This makes production of certain goods much cheaper in some countries than in others, distorting the competitiveness. Under the Kyoto Protocol signatories are only committed to economy-wide cuts. While this flexibility is one of the strengths of the Protocol, it can also be a liability when it comes to competitiveness. Countries are free to make cuts according to domestic considerations, but these considerations can be political rather economic or environmental. Countries can shield certain industries from abatement obligations, making them more competitive relative to producers in countries where the sector is regulated (Sawa (2008) and Philibert (2005)).

When internationally competitive industries are regulated, one often hears the argument that it will hurt their competitiveness (Bradley, Baumert et al. 2007). These industries can be well organized and powerful domestic pressure groups, making it politically difficult to introduce abatement measures. If these sectors were given assurances that the same rules would apply to all major producers of this good, it might silence this opposition. This result hinges on that the good in question is not easily substituted by some other, unregulated good.

Again, all loss of competitiveness is problematic for those it concerns. But the purpose of the climate policy is to reduce the profitability of carbon-intensive production in favor of more emission-friendly production. If an agreement seeks to limit all competitiveness issues, it runs the risk of not being very efficient. Sectorial agreements can be designed so that they limit competitiveness concerns within a sector, while at the same time imposing efficient measures on the industry as a whole (Bradley, Baumert et al. 2007).

4 Instruments

There are three main instruments available when considering a sectorial environmental agreement; technological standards, taxes and transferable permits. There exist a number of other instruments as well, most notably subsidies.

Subsidies are essentially negative taxes. The regulator gives certain sectors or firms subsidies, either in the form of tax relief, direct transfers or other economic benefits. This improves the sector's competitiveness by reducing its costs. Aside from redistribution in exchange for participation or some R&D fund, subsidies are seldom discussed as an alternative instrument for global environmental agreements. This can partly be explained by the neo-classical, liberal economic tradition. It is a strong proponent of the view that to support certain sectors can be more harmful than helpful to the economy. It distorts incentives in such a way that it might keep unprofitable sectors artificially alive. But it is also simply because subsidies cost money that no one is willing to use. There is no global government with a large treasure chest.

There has been much discussion of what could be done with the revenue raised from either a tax or permits auction, using it either to fund R&D or technological improvements to plants and equipment in developing countries. Evidence from a survey by Harrington and Morgenstern (2007), covering different environmental problems were the US and European countries chose different instruments, revealed that in five of six cases, the revenue raised by either taxes or permits had to be reimbursed to the firms. This suggests that subsidies largely is a means to make taxes or permits more acceptable, rather than being a choice of instrument. I will therefore not go further into the issue of subsidies in this paper, and rather treat alternative uses of any revenue created from taxes or permits as properties of these instruments.

When discussing the instruments, standards, taxes or permits, I will evaluate their compliance with the same six criteria used in section 2 and 3; cost-effectiveness, participation, compliance, environmental effectiveness, carbon leakage and competitiveness. There are no definite answers. An instrument can fit one problem perfectly and achieve poor results when used on another. All observations in this section will therefore be general, before the instruments are applied to maritime sector in the next section.

4.1 Command-and-control instruments

Command-and-control instruments can be defined as laws or regulation of an industry or activity that describes what is legal and illegal. The command part is precisely this; a regulator decides

what kind of production should be allowed, which inputs can be used and what technology must be used. The control part is monitoring and the potential punishment for non-compliance. Until the end of the 1970's, almost all environmental regulation was command-and-control instruments (Harrington and Morgenstern 2007).

Technological and performance standards are two types of command-and-control instruments. Technological standards are used to abolish old carbon-intensive technologies or inputs in production or to impose the use of new technology. Performance standards are requirements on the output of production, e.g. that the ratio of kg emission per MT fuel used in production is below some threshold value. This allows the firms flexibility in choosing how to meet the requirements, either by using new technology or changing the input mix. The market price of the good will rise as a result of investment or adjustment costs, but the firms do not have to pay anything for the remaining emissions. The market price of the output would be lower than if the firms had to pay for permits or taxes, and consumers will not have as strong an incentive to substitute the good.

Critics of the command-and-control instruments generally accuse them of being blunt, costly and lack accuracy. Proponents argue that they ensure certainty about costs and produce quick results. I will in the following go through each criteria used on environmental agreements and discuss whether command-and-control instruments are suited to address these issues.

Command-and-control instruments are generally perceived not to be cost-effective. Setting a specific technological standard instead of letting firms themselves choose how to abate violates the least-cost theorem of pollution control; marginal abatement costs will differ between firms. It is very unlikely that the regulator has enough information to be able to design standards that creates equal marginal costs for all firms, if that is even possible. This problem is only amplified when trying to gather to set global standards. Some firms might only need small improvements, while others will have to make costly investments. In this scenario, the combined abatement would be larger if the low-cost firm were required to contribute to a larger share of the abatement.

Tietenberg (1985)[1] gathered results from 10 different studies, comparing command-and-control emission control with least-cost. He found that the cost-ratio ranged from 1.1 to 22.0. This very strong result and others like it (e.g. Goulder, Parry et al. (1999)) is often used to prove the ineffectiveness of command-and-control instruments. The problem is that the comparison should have been made between actual command-and-control and actual market based mechanisms, not between an actual instrument and a theoretical first-best (Stavins 1995). Several studies have found that market based measures do not preform as good as anticipated by models (e.g. Atkinson and Tietenberg (1991)) strengthening the argument that while command-and-control instruments are not cost-efficient in theory; neither is market based measures in reality.

Evidence from both Goulder and Parry (2008) and Harrington and Morgenstern (2007) suggests that while the opposite is most often the case, there are situations where command-and-control instruments are virtually cost-effective. If regulation is so stringent that practically all available abatement measures must be taken, there is not much to gain by ensuring flexibility. Also, if the sector is homogenous, then the standards will have approximately equal marginal abatement costs, and thus be cost-effective.

The second criterion is participation. Command-and-control instruments are very technical and specific, and can thus be difficult to negotiate because domestic interest groups oppose certain requirements. On the other hand, the fact that standards are very specific makes it easier to estimate the costs of compliance. This certainty might make the agreement more agreeable to special interest groups (Philibert 2005), and thus fitting for a sectorial agreement. Because command-and-control instruments do not require firms to pay anything for their emissions, only the abatement, the cost is often perceived to be lower for the individual firm. This make many firms prefer command-and-control over other instruments, and hence make them more inclined to support the agreement (Harrington and Morgenstern 2007). The support of individual pressure groups is even more important in sectorial agreements than economy-wide, as there is no room for compromises between different sectors within the agreement.

It is not easy to say anything about whether command-and-control instruments can ensure compliance or not, as this is more a feature of the agreement than the instrument. It is however

[1] Cited in Stavins, R. N. (1995). "Transaction Costs and Tradeable Permits." Journal of Environmental Economics and Management **29**(2): 133-148.

many sectors that already are subject to national and international health and safety standards. Some sectors and some countries are better at fulfilling these obligations than others. Environmental regulations will naturally face the same kinds of challenges as other regulations, and a well-functioning controlling body is necessary. When assessing a sector's expected compliance, its record on other regulations can work as a good proxy.

Environmental effectiveness can best be achieved when the firms are free to choose means of abatement. Technological standards are not flexible, and the same measure might not be as effective for all firms. Performance standards are better, as these just define some minimum requirement on the quality of the output, leaving it up to firms to decide how to reach this target. This can also incentivize R&D, as firms would want to find cheaper ways to achieve abatement. This argument has its negative counterpart: command-and-control instruments can deter firms from research because it might lead to even more stringent requirements in the future. The environmental effectiveness can be compromised further if firms postpone retirement of older plants, ships or equipment, because requirements often apply to new acquisitions. The main problem with command-and-control instruments' effectiveness seems to stem from the fact that they only encourage cost-reducing, and not emission-reducing (Harrington and Morgenstern 2007). As command-and-control instruments would have to be sector specific regardless of whether they are part of a sectorial or economy-wide agreement, there are no reasons to believe that the environmental effectiveness of the instrument would be influenced notably by choice of agreement.

Carbon leakage is, like compliance, more a property of the agreement than the instrument. The cost of compliance will depend on the specifics of the requirements as well as the state of existing equipment. On the one hand, replacing old equipment with new might make the overall production cheaper as well as more environmentally friendly. On the other hand, firms using old technology will have to make more investments to meet the new requirements. Depending on which effect is the stronger, the incentive to move production to an unregulated country can be strong or irrelevant. Command-and-control instruments are at a disadvantage from taxes and permits in that they do not raise any revenue that could be used as a subsidy to counteract any such incentive. But as mentioned above, the costs of compliance for firms are perceived lower under command-and-control instruments overall. This will discourage relocation to unregulated

countries, as the rewards are lower. If the marginal abatement costs are very different between the firms, the firms with highest costs will be most tempted to relocate. This effect differs from taxes and permits, where individual firms pay taxes or buy more permits if it is too costly to reduce the emissions.

The sixth criterion is competitiveness. Technical or performance standards will undoubtedly be an expense in the short run that could hurt the competitiveness of regulated firms. But as the costs to the individual firms are perceived to be lower, this effect might not be as important for command-and-control instruments. Assuming that sectorial agreements will ensure better participation, this problem will be even smaller.

Overall, the biggest concern about command-and-control instruments is their cost-effectiveness. The evidence of large cost gaps between command-and-control and market-based instruments cannot be ignored, even if there are large differences from case to case. At the same time, standards have some qualities that can make them more politically feasible. If the alternative is nothing, standards can be a good solution.

4.1 Carbon tax

Where technological and performance standards are imposed as minimum requirements, market based measures like taxes and tradable permits are meant to create economic incentives to act in a certain way. By taxing some unwanted input in production, the government effectively alters the structure of payoffs that the firms face. The firms are free to do as they choose, but the cost is higher the more they pollute. This internalization of the environmental cost incentivizes the firms to take any cost-reducing actions. Firms can then choose between paying the tax, installing new technology or substitute the polluting input.

A tax on an easily substituted input will have larger effect than a tax on an input with a low *elasticity of substitution.* The elasticity of substitution is a measure of how easy it is to substitute one input for another. There are two effects: increased spending on the taxed good because the relative price rises and the fall in relative demand, resulting in reduced spending. If the first effect is larger than the second, the elasticity of substitution is low. The increase in prices does

not result in less spending on the taxed input. Rather, the output will be more expensive, leaving it to the customers' elasticity of demand to decide whether the use of the taxed input will be much affected or not. If the second effect is larger than the first, the elasticity of substitution is high. The effect of higher relative prices will reduce the firm's spending on that input, substituting it with another.

The effect of a tax will therefore largely be dependent on the nature of the good taxed and the elasticity of substitution. Deciding whether a tax will have the desired effect therefor requires a thorough analysis of the good in question. In a sectorial agreement taxes will likely be set globally and either be collected through the home states or directly to some international regulator. The revenue raised can be used to support R&D or financial support to firms for installing new technology. How does this scenario fit with the six criteria?

Taxes are generally thought of as cost-effective. They give each firm an incentive to abate up to the point where the marginal abatement cost equal the price of the tax, thus ensuring that marginal abatement costs are equal across all firms. Where all taxes distort, environmental taxes are created to correct a distortion. Whether or not they actually achieve this goal and not create a deadweight loss, is entirely up to the design of the agreement.

The perhaps largest problem with taxation is participation. Taxes are not popular. Especially if the taxes are international, and the raised revenue is distributed by an international regulator. It is the domestic government that will be blamed for these new taxes, and they will not even have more revenue to show for it. We often see what can be described as a revenue dilemma: If the tax is high enough to have an effect, no country will sign the agreement. If the tax is too low, it will miss its target (Pearce 1991). The trick is to get the countries to agree on a tax level sufficiently high to make a difference.

Tax evasiveness is a big problem in large parts of the world. If an environmental tax where to be administered nationally, there are good reasons to question the compliance rate. It might be more reliable with a tax administered at a sectorial level, as it often already exist international institutions that can keep an oversight with the industry. The sectors that are considered as candidates for a sectorial approach are large, international, fairly homogenous and already much regulated sectors. There are mechanisms in place to ensure compliance. One of the advantages of

taxes is also that it is can be easy to adhere to for the firms. If the tax is collected through suppliers, all firms would have to do is pay a premium. If the tax is based on actual emissions it will demand a bit more record keeping for the firms, but this is often records that the firms already keep (Bradley, Baumert et al. 2007). This will minimize the administrational costs, and thus the overall cost of compliance.

As opposed to command-and-control instruments, taxes ensure continuous incentives for more abatement, making them potentially more environmentally effective. If the tax is too low, this continuous effect will be small. Firms will only see the tax as an increase in production costs that is too small to warrant any changes. The environmental effect will therefore mostly be through the use of the raised revenue. If that revenue is used for R&D or to subsidize new technology, this will have a positive effect. If the tax in is of a non-negligible size, the effect will both be through the firms' incentive to cut emissions to reduce the tax burden, as well as the use of the tax revenue. This effect can be markedly bigger than the environmental effect seen under command-and-control instruments.

Carbon leakage poses a serious challenge when imposing any national tax on a competitive industry. When California introduced an 8,5% sales tax on maritime fuels in 1991, sales dropped by nearly 80%. Ships refueled in Panama instead, to avoid the cost. The tax was rescinded only a year later (Michaelowa and Krause 2000). This example illustrates the importance of a global agreement. Any tax set that is not global, could be severely undermined by carbon leakage. If a sectorial agreement indeed could attract more participants within the specified sector, one could assess the costs of a decrease in cost efficiency versus the reduction in carbon leakage. For an agreement that does not have full participation, carbon leakage could still be avoided by imposing trade restrictions or other market barriers for goods produced in unregulated countries. If the gain of being part of the agreement is bigger than the cost of compliance, firms will not relocate to unregulated countries.

Taxes clearly are a cost for the firms, assuming that they cannot roll over the entire cost on consumers. Any extra cost will raise some concerns about competitiveness. But a target for emissions reduction already exists for many of the most emitting countries, either self-imposed or part of the Kyoto agreement. In order to comply with these targets, there are going to be costs,

regardless of instrument chosen. Taxes are relatively simple and they create revenue that can be used to offset some of the firms' costs.

4.2 Transferable permits

Tradable permits are quotas distributed between firms or countries, stating how much they are allowed to pollute. It is also possible to have an uncapped system of permits, where firms always can buy more permits. This alternative is quite similar to taxes, as the regulator will not be able to decide the total emissions. I will therefore concentrate on the systems where there is a cap on total emissions.

The total emissions are decided by the regulator, but how it is distributed is decided by the market. Firms with low abatement costs will choose to abate more and sell their permits up to the point where their abatement cost equal the price of the permits. Firms with high abatement costs will rather buy permits than take expensive measures, up to the point where the price of permits is higher than their abatement cost. In equilibrium the emissions will be the amount set by the quotas, but the price of the permits is decided in the market and will equal the marginal abatement cost of all firms. This regime differs from taxes in that the regulators can be sure about the outcome, but not the price.

There are two main alternatives in distribution of the initial permits. They can be given free of charge to firms according to which firm polluted more previous years, so that all firms have the right to pollute the same amount or the same share of total as before. This alternative, called grandfathering, favors existing firms that are large emitters, as they can choose to sell or keep their permits. Alternatively, all firms must buy the permits they need at an auction, and can later buy and sell between themselves.

Grandfathering is clearly the most politically popular alternative of the two, and is thus also most widely used. The general view among economists on the other hand, is that auctions are the better way to go. Auctions can raise funds that can be used to subsidize R&D or abatement in developing countries, funds that even can replace distortionary taxes. Keeping in mind the two alternatives, how well do permits address the criteria for an efficient environmental agreement?

Tradable permits ensures that all firms face the same marginal abatement cost equal to the price of the permits, and are hence cost-effective. However, there are several distorting factors. If there is owner concentration in the permits market, large holders of permits can influence the price (Hahn 1984). If the output market is not competitive, permits might reduce the social welfare compared with command-and-control instruments (Malueg 1990). Preexisting tax regulations might also influence performance, and more so for grandfathering than for auctions (Parry, Williams et al. 1999). The existence of transaction costs can limit the permits' efficiency. It can either be difficult to identify potential buyers or sellers, or firms might need additional help of lawyers when bargaining. The fact that firms actually pay high fees to brokers to handle their permits, is proof that these transaction costs exists (Stavins 1995). In a survey done by Atkinson and Tietenberg (1991), it was shown that trading levels, and therefor also cost savings, in permit markets were lower than anticipated beforehand by models. There is also a considerable bias toward internal trading within firms. All these different factors must be assessed when debating to use permits in a sectorial agreement.

Permits have been shown to be more politically feasible than taxes, and might therefore do better when it comes to ensuring participation. Where there are no good examples of supranational environmental taxes, there have emerged several tradable permits schemes in recent years. Most notably the EU Emissions Trading System (EU ETS) that also includes Norway, Lichentstein and Iceland. The EU ETS covers 45% of the EU's emissions, including aviation within the EU and EFTA. Other national or sub-national systems are already operating in Australia, Japan, New Zealand, Switzerland and the United States, and are planned in Canada, China and South Korea (EC 2013). One of the advantages of tradable permits is the possibility of linking such national initiatives to a global framework in the future. The same goes for sectorial permits. If one sector is singled out for a special permit scheme today, it can be linked to other schemes in the future.

The initial distribution of permits might influence the participation as well. Grandfathered permits have been criticized for being regressive, i.e. redistributing income to the wealthy (Parry 2004). The free permits are registered as higher equity in the firms, to the benefit of shareholders who tend to be relatively wealthy. Alternatively they could have been sold at an auction, raising revenue that could have been recycled as tax reductions or R&D that benefit everyone. The same is true for taxes, and although the government does not earn revenue on command-and-control

instruments, they do not give the wealthy rents either. This argument is originally made studying domestic instruments, but the same could be true for international agreements. A large share of the world's ownership is concentrated in developed countries, and the revenue raised by auctions or taxes could have been used to support R&D or projects in developing countries. Considering that developing countries already are of the opinion that it is the developed countries that should bear the burden of climate policy, they should be very skeptical to the idea of grandfathered permits.

As with taxes, compliance with the sectorial permits scheme could be secured by creating barriers to trade with, or operation in, countries that have signed the agreement. Only firms that have bought the requisite number of permits are allowed to sell their goods to countries in the agreement. As previously mentioned, there is some research suggesting that there is large transaction costs associated with permits. If compliance is costly to firms, the reward of non-compliance is even bigger. The agreement must include a credible threat and minimize firms' administrative costs to ensure compliance.

One of the professed big advantages of tradable permits is that they have a certain environmental effect. The cap limits total emissions, and the environmental effectiveness is thus more of a political question. There is a possibility that it is politically more difficult to set a stringent target in sectorial agreements than economy-wide agreements. In the latter, you have the advantage of linking different sectors, so that each country can compensate one very carbon-intensive sector abating more in others. If all countries are to set a target on one sector alone, countries where this sector is comparatively carbon-intensive would want this target to be as high as possible. A high target will limit the agreement's environmental effectiveness.

Carbon leakage is more probable the higher the cost of compliance with the agreement. If a target is set too low, the price of permits will rise. If this cost is sufficiently high; firms will find it cheaper to relocate to a country not part of the agreement rather than buy costly permits. This outcome is possible under an economy-wide IEA without full participation, where there are large differences in abatement costs or willingness to pay. If one sector has very high abatement costs, they will buy up all the permits rather than abate. This will increase the marginal operational costs in other industries, making it more attractive to relocate. If you instead were to have a separate sector agreement for the sector with high abatement costs, you could have higher permit

prices in this sector, to ensure that the sector abates, without risking carbon leakage in other sectors (Zetterberg 2008).

Nothing about tradable permits suggests that they would lead to more competitiveness issues than taxes. Higher participation creates less distortion, regardless of instrument. However, the choice of a sectorial agreement might create some competitiveness concerns in itself. If the good produced by the sector in question could be substituted by a product produced in another sector, then that whole sector would get a competitive advantage by not being subject to the sectorial agreement. Aluminum production is often referred to as a strong candidate for a sectorial agreement. If the cost of aluminum would rise too much as a result of this, the use of aluminum in buildings could be replaced by e.g. steel or iron. Firms might have competitors in several sectors, creating additional concerns over competitiveness.

All in all, tradable permits are preferable if it is especially important to keep the total amount of emissions below some threshold. It is questionable whether this is an important trait in a sectorial agreement. Grandfathered permits are also more politically feasible than taxes, making participation possibly easier to ensure. Lastly, a sectorial permit system can relatively easily be linked to other permit systems in the future, improving cost efficiency. However, as mentioned above, this can also have some adverse effects, e.g. carbon leakage. Because the target is set politically, prices may vary with demand. If the prices are sufficiently volatile, this might create a significant uncertainty about future costs. Uncertainty about costs can have adverse effects on investments, as the benefit of abatement is uncertain. A closed permits system for only one sector might cause even larger fluctuations in the price, strengthening this effect.

4.3 Comparisons

Command-and-control instruments are a solution to a problem of unwanted activities. Emission is harmful to society and the economy in the long run, and should therefore be subject to constricting laws, just like other harmful or unwanted activities.

Taxes are a Pigouvian solution to a problem of externalities. Emissions are an external cost of production that has to be internalized by firms, in order for the market to behave properly. By issuing a tax equal to the marginal external cost, all market actors will adjust accordingly and the level of emissions will be economically efficient.

Permits are a Coasian solution to a problem of undefined property rights. Clean air and a stable climate are not owned by anyone, and are consequently suffering the tragedy of the commons. If ownership was clearly identified, all vested parties would reach an agreement to ensure a socially acceptable solution. Marketable permits are the right to use a quantity of fresh air.

While command-and-control instruments have the obvious disadvantage of not being cost efficient but advantage of being easier to implement, it is less clear when the other two are suitable. As Weitzman (1974) writes in his seminal paper, taxes give regulators certainty about price, but might miss the target. If taxes are too low, firms will choose the tax rather than abatement measures. On the other hand, permits give regulators certainty about quantities. If the quantity is too low, firms will be forced to undertake very costly abatement measures. Weitzman concludes that when there are uncertainties about the cost of abatement, the choice of instrument will depend on the steepness of the benefits curve.

If the marginal benefits curve of emission abatement is steeper than the marginal cost curve and the regulator were to choose a too low tax, the cost in terms of emission would be high. Taschini (2010) liken it to a threshold effect: if emissions exceed some threshold, dire consequences follow. In this scenario, it would be important for regulators to be sure that the quantity of emissions do not exceed this threshold. Permits allow for this, and are thus the best choice.

If the marginal cost curve of emission abatement is steeper than the marginal benefits curve, the situation is reversed. If the regulator imposes a too stringent permits system, the firms are forced to pay excessive costs for abatement. Under the tax alternative, they could opt out and just pay the tax when abatement costs are too high.

So are taxes or permits the better choice when it comes to greenhouse gas emissions? CO_2, the most important greenhouse gas, is a stock pollutant, meaning that the emissions stay in the atmosphere for a long time. It is the accumulated stock that is most harmful, not the flow. The yearly flow of CO_2 is small compared to the stock in the atmosphere. The marginal benefit of

abatement is consequently a quite flat curve, because abatement at any given year will only be a small contribution to alter the existing stock (see Newell and Pizer (2003) and Hoel and Karp (2002)). This weighs heavily in favor of tax instruments. When looking at a sectorial regime, this argument is strengthened further. The total annual emissions from any one sector will be relatively small compared to the overall emission stock, and it will not be as important to regulate the exact quantity. Sectorial agreements could therefore be especially suited for taxes.

Pizer (2002) looks at uncertainty about compliance costs and simulates the welfare gains from taxes and permits. The result is that the expected gain from taxes is five times higher than the expected gain from permits. This strong result comes from the assumptions of a relatively flat marginal benefits curve. If we instead assume a very steep marginal benefits curve, the results are reverted. However, Pizer argues that if the damages from climate change were that abrupt and catastrophic, any abatement measure would have such enormous welfare gains that the difference between them would be insignificant. As the chance of emissions from one sector causing such sudden damages is even less likely, this argument holds particularly true for sectorial agreements.

The theoretical evidence is quite clearly in favor of taxes. CO_2, the most important greenhouse gas, is a stock pollutant, making the marginal benefit curve of abatement relatively flat. Much of the damage has already been done, and what can be abated yearly has only little impact on the size of the stock. Also, the aggregated emission of one sector has comparatively very little impact on the size of the stock. That this flow is below some threshold is not a primary concern, the primary concern is a steady decline. This also points to taxes. The potential volatility of permits prices and the uncertainty it creates for investors further strengthens the argument for taxes.

5 Maritime sector

About 90 percent of all world trade is carried by sea. The general trend the last century has been large increases in trade volume. The shipping industry emitted 949 million MT CO_2 in 2012,

which corresponds to 2.7% of global emissions in 2012 and an average of 3.1% over the previous five years (IMO 2014). Emissions from international shipping, responsible for about 85% of all emissions from shipping, nearly doubled from 1990 to 2005, a period where total emissions increased by 28% (Faber and Rensma 2008). It is estimated that the emissions will grow by a factor of 2 to 3 by 2050 compared to 2007. If we are to reach the 2^0C goal by 2100 with a 50% probability of success without reducing emission from shipping, the sector would be responsible for between 12% and 18% of global CO2 emissions by 2050 (IMO 2009).

Despite the sector's fast growing emission rate, the sector was intentionally cut out of the Kyoto Protocol: "The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively" (UNFCCC 1997). The reason was that emissions from both international aviation and shipping were difficult to allocate to any national emission totals. The UNFCCC therefore thought it better to use a carve-out model and deal with these emissions separately.

The industry itself stresses the fact that shipping is the most energy efficient mode of transport of goods. In fact, large container vessels emits 3 grams CO_2 per tonne-km, road trucks emit 80 grams per tonne-km and air freight 435 grams per tonne-km (IMO 2009).That means that if all air cargo were instead transported by ship, this would reduce the CO_2 emissions per tonne-kilometer by over 90% (Michaelowa and Krause 2000). Too costly regulations on the maritime sector could drive up prices, making the alternative transport modes more attractive, thus actually increasing the total emissions of CO_2 instead of reducing it.

Still, no one really disputes the need for abatement. In the following section I will first assess whether the maritime sector is a match for a sectorial approach. In the second subsection I will give an account of the IMO and its progress (or lack thereof) before I will evaluate the efficiency of the three proposed instruments: standards, taxes and a system of tradable permits.

5.1 Does the sector fit?

The five criteria for a good fit listed in section 3.1.1 were (1) that the sector was either responsible for a sufficiently large share of emissions, or would be in the future, (2) that there was a significant potential for emission reduction, (3) that the sector had a large concentration of actors, (4) that there was a high level of trade and (5) that there was some homogeneity of production.

As mentioned in the previous section, international shipping is responsible for about 85% of all shipping emissions, resulting in 2,2% of global emissions. Based on numbers for each country's CO_2 emissions in 2010, that is more than countries like Germany, Canada, the UK and Australia. It is more than the entire Central Europe and the Baltic states. In fact, there are only seven countries (the EU included) in the world with more emissions. That is a substantial amount of emissions, even if those seven countries alone are responsible for over 65% of total emissions (World Bank 2015). That should be enough to pass the first criterion.

The second criterion is potential for reduction. IMO has identified a number of cost-efficient technical an operational measures to reduce emissions. Estimations predicts that the yearly emissions could be reduced by 25% to 75%, depending on which measures are implemented (IMO 2009). In addition, there are several proposed market-based measures. The fact that there up to 2011 was no mandatory abatement measure in place for international shipping should be a good indicator to the fact that there might be some low hanging fruits in the sector. Still it is important to note that abatement will probably be costly. Fuel costs in international shipping amounts to over 60% of operational costs depending on the ship type, so most operators have already implemented fuel efficiency measures where they are easily achieved.

The third criterion, defining the concentration of actors in international shipping, is tricky. Who are the main actors? Is it the flag state? Or is it the owners, the operators or the management? The shipping industry has a notoriously complex ownership structure. The flag state can easily be changed when convenient; the number of ships registered in the OECD in the beginning of the 1980's was 51% of world tonnage (Michaelowa and Krause 2000). In 2013 it was reduced to under 20% (UNCTAD 2013). Nothing in trading data can explain this, as available data suggests that most of the traffic still goes between and to Annex I countries (Wang, Corbett et al. 2007). Ships are often owned through banks or holding companies, and then leased to operators on long-term contracts. All operational costs are incurred by the operators, who will not have the

same incentive to make improvements as they would if they owned the ships. To complicate things further, there are large differences between the different kinds of shipping.

Within container liner shipping, one of the main groups of activities in international shipping, there has been an increasing degree of concentration since the 1990's resulting in an oligopoly like market (Blomme 2005, Sys 2009). In 2003, the top five liner shipping companies controlled 48% of the slot capacity (Notteboom and Winkelman 2004). In the remainder of the sector, all the ships that do not work by specified schedules and trading routes, the picture is much more diverse. With the exception of a few very large bulk and tanker companies, much of the sector comprises of smaller companies. The sector is however, largely coordinated through alliances and organizations. So while we do not see the same degree of concentration as e.g. aviation, it is present in some part of the sector, as well as on the organizational level. E.g. IMO speaks for has 170 member states (nonmember states are mostly landlocked) and the International Chamber of Shipping represents 80% of the world merchant fleet (ICS 2014). If looking at percentage of global merchant fleet ownership, the top five countries own more than 50% of total deadweight tonnage. The top 35 countries own 94.55% (UNCTAD 2013). Considering that most ships go in traffic between different countries not that many of these 35 countries would have to sign the agreement in order for it to be virtually global.

The fourth criterion is easier to assess. International shipping is literally international. Goods are transported between two countries by a ship registered in a third country that is owned by a multinational company. This is the reason why international shipping was left out of the Kyoto protocol in the first place – the high level of international exposure necessitates a truly global initiative. The industry itself is more concerned by competitiveness issues than to avoid emission commitments (ICS 2014).Even though this does not seem to have helped notably, the EU's threat to include maritime emissions in the EU ETS if the IMO do not find an alternative soon might make the matter more urgent (Åhman 2008).

The last criterion is homogeneity in production. First of all there is a large degree of specialization in shipbuilding. Ships are most often custom made and serve a wide range needs, from cruise ships to tankers. The emission intensity varies immensely. But there are similarities. All of them have hulls and propellers that could be regulated by relatively simple standards, making them safer. R&D on fuel efficiency could be equally valuable in production of a bulk

carrier as a container ship. The production is not as homogenous as e.g. steel or aluminum, but the technology used in production is similar enough to be set to sector wide technology standards and for it to benefit from cooperation.

Production in the maritime sector could also mean the production of shipping services. A significant part of the sector is transport of goods, where the ship owners and operators produce a service. If a company wants to send a container somewhere, it would fit on any container ship. This service is very homogenous; most companies do not care if it is a Maersk or an Evergreen transporting their goods. It is more difficult to compare the service of a cruise ship with that of a tanker. Where tankers and other transport vessels use most of their fuel consumption on propulsion, much of cruise ships' emissions come from heating, cooking, entertainment and other services relating to the passenger experience. Cruise ships are basically providing the combined service of transport and hotel. And although cruise ships generally emit less than large cargo ships, they emit significantly more than aviation per passenger-kilometer. They also emit 12 times as much as a land-based hotel resort (Howitt, Revol et al. 2010). Shipping is generally environmentally friendly when it comes to transport of goods, but very unfriendly when it comes to transport of passengers.

Maritime sector seems to have something to be missed when it comes to homogeneity. But by dividing into a few different categories, transport of good or people, the IMO has proven that it is not impossible to make sector-wide standards. Most of the existing regulation is type-specific. If an agreement where to have a lot of exceptions, either by excluding small vessels or passenger ships, that would affect the environmental effectiveness, but it would not be impossible.

The international maritime sector is generally thought of as a good candidate for a sectorial approach, but perhaps more because it is so sensitive to the short-comings of an IEA than because it fits the criteria of a sectorial agreement so well. There is a very high elasticity of substitution in the choice of ports (Michaelowa and Krause 2000), making the sector very vulnerable for carbon leakage. Broad participation and a solid institution that can enforce and monitor seems like important features of any maritime agreement.

5.2 The IMO and two opposing policies

The International Maritime Organization (IMO) got a mandate from the UNFCCC in 1997 to create a separate agreement on bunker fuels. Now, 18 years later, little has happened. It is a widespread understanding in IMO that market-based measures are a more efficient way to go, and that IMO should be the ones to implement and administer it. But the process has been excruciatingly slow and mostly concerned with data collection and voluntary technical and operational measures (IMO 2011).

One of the main reasons why the process has been so slow is the inherently different approaches of the UNFCCC and the IMO. The UNFCCC works after the principle "common, but differentiated responsibility", a compromise that acknowledges the fact that industrialized countries historically have contributed much more to the stock of greenhouse gases in the atmosphere than developing countries and that there is a correlation between economic growth and emissions. This correlation is more a result of old, carbon-intensive technology than any inherent trait of emissions. There exists sustainable technology now (or in the near future) that can ensure growth without as high emissions. But this new technology is expensive, and who should pay the bill?

Most developing countries have refused to let the international community set caps on their emissions. New technology is expensive and the future gains of economic growth seem greater than the cost of reducing emissions. For most of them, this is also true in the near future. Damage caused by climate change is not geographically correlated with emissions. Countries like the Maldives, which see rising sea levels as a very real threat, are more inclined to take actions now. Other countries see poverty as the larger problem, and demand that the original polluters are the ones that should take the bill. "Common, but differentiated responsibilities" is the principle that ensured participation from developing countries, and without it, it is unrealistic to even imagine a new environmental agreement. The Kyoto Protocol might have been faulty from the start, but any new climate agreement would have to deal with the differentiated responsibilities some way or another.

IMO's policies, on the other hand, are based on the principle "no more favorable treatment", i.e. equal treatment for all ships, regardless of flag state. This principle stems form a time were ships

were given different treatment in ports based on their flag. The IMO was founded on the idea that a global industry needed global rules and regulations. Regulations agreed upon in the IMO would be enforced in the countries that have ratified the new convention, but would apply to all ships visiting these countries, regardless of whether the flag state had ratified the regulations or not. No ship should be put at a disadvantage because their country had ratified the convention, and as a result, no ship would be treated differently if their flag country had not ratified the convention. If a ship that came to port did not comply with the regulations, port authorities could detain the ship.

The IMO have an impressive record of making regulations, but has been criticized for lacking the necessary executes powers to enforce these regulations. Non-compliance with IMO regulation can reduce annual operating costs by as much as 15%, according to one estimation (Michaelowa and Krause 2000). Between the years 2002 and 2009, between 45% and 55% of all inspected ships had faults. But over the same time period, the percentage of detained ships has dropped steadily from over 8% till around 5%. This suggests that while there is a steady and large number of discrepancies, the number of serious discrepancies is decreasing (IMO 2010). While not being anywhere near a perfect compliance rate, it is not entirely discouraging.

Because the IMO has been given a mandate by the UNFCCC through the Kyoto Protocol to make regulations for maritime emissions, the question arises as to how these to principles can be combined. Developing countries insists on differentiated responsibility, while the IMO refuses to go on accord with its own principle. This dilemma has resulted in essentially two options.

The first option is to have uniform policies, but that a larger share of the costs fall on Annex I countries. This could be accomplished by a revenue raising tax or permits auction, were all the revenue were used to subsidize developing countries. It could either be a direct reimbursement or a subsidy on abatement measures. The latter is of course more environmentally efficient, but would only indirectly reduce costs for developing countries. They would still experience a rise in operational costs that could influence e.g. import costs. This alternative would be hard to evade, as all emissions would be included.

The second option is to differentiate commitments so that only routes to and from Annex I countries are liable. This alternative would be closer aligned with the UNFCCC principle of

differentiated responsibilities and would not affect trade between developing countries. It would however open up to a range of evasion opportunities that would undermine its effect.

Under both alternatives, the Port State Control (PSC) would play an important role in enforcing these regulations. The PSC is a result of several regional ”memorandums of understanding” between coastal states. The agreements allow the regional PSC to inspect all ships in port and ensure that they comply with national and international regulation. If the requirements are not met, the PSC can demand that the shortages are rectified within some time limit or it could detain the ship until the deficiencies are rectified. The PSC has proven quite efficient; every ship was inspected on average 1.3 times a year in Europe in 2013. Out of nearly 18 000 inspections, 58% of them resulted in the recording of a deficiency and 3.7% of the ships were detained (PSC 2013). Detentions have been related to health and safety hazards and not environmental regulation, but if the agreement is sufficiently strict, detention should be used for breach to the environmental agreement as well.

IMO is considering ten different proposals for greenhouse gas abatement policies (IMO 2011). Two of these proposals are additional efficiency standards, three of them are tax-based and three permits-based. They are all intended to be global in scope, even though some member states still oppose this idea. All of them could however in theory be scaled down to only apply to ships in routes to and from Annex I countries.

5.3 Command and control: The EEDI and the SEEMP

In 2011, the shipping industry became the first industrial sector covered by a legally binding agreement to reduce its emissions. The Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP) entered into force in 2013. The EEDI is a technical standard of fuel efficiency that all new ships must uphold. The SEEMP is an operational standard for more efficient energy use. Unfortunately, as the EEDI only applies to new ships, it will take some time for this to take effect. Most vessels have long lifespans. The average age of a container vessel is 10.8 years, while it is 25 years for general cargo vessel. However, as new ships are much bigger than old, 40% of ships by deadweight tonnage is less

then 5 years old(UNCTAD 2013). Isolated, this instrument can provide an incentive to keep old ships in use longer, to avoid the extra regulation imposed on new ships. Combine that with the recent downturn in the world economy, and it is clear that the EEDI is far from sufficient.

The SEEMP will be required for all ships, but its effect is more questionable than the EEDI. It basically is a plan or list of possible measures that is must be made specifically for each ship. But once it is made, there is nothing forcing or even incentivizing operators to follow up on these steps. All that is required is that the piece of paper is present on the ship, in case of a port state control.

In addition to these two measures, it has been proposed to introduce efficiency standards for existing ships as well. If a ship fails to meet the standards, it would have to either buy credits or pay a fee. The suggestions have been made by the United States and the World Shipping Council, respectively. While the two new proposals have some market elements, they are all essentially command-and-control instruments. But how do they measure up against the six criteria of a successful agreement?

The EEDI specifies industry wide standards, and therefore does not have the flexibility needed to be fully cost-efficient. The SEEMP is much more flexible, but is not mandatory to enforce. However, the administrative costs of the EEDI has been shown to be very small compared to other instruments (IMO 2009). So for small reductions in emissions, where administrative costs are a large share of total costs, these instruments might not be more expensive. And they have ensured widespread participation – the EEDI and SEEMP are already ratified by over 94% of the world fleet (ICS 2014). The previous success of the Port State Control in reducing the number of substandard ships bodes well for the compliance rate of the instruments.

As for environmental effectiveness, the combined effort of both EEDI and SEEMP will reduce annual emissions by 200 million MT CO_2 by 2020, according to IMO's own estimates (IMO 2011). The annual reduction will increase as more and more old ships are replaced by new. A standard including all ships, like the ones proposed, would have a larger and swifter effect. However, because these measures are restricted to technical measures, they will not achieve the same level of environmental effectiveness as operational instruments.

The very high ratification rate will ensure that carbon leakage is avoided. The low costs and scope of the regulations make competitiveness issues with other modes of transport unlikely. Even if the regulations should be expanded to include all ships in the future, this will most likely be the case for road transport and air freights as well.

5.4 Carbon tax: the ICF

There have been three different tax proposals discussed by IMO's Expert Group on Feasibility Study and Impact Assessment of possible Market-Based Measures (MBM-EG) (IMO 2011). The first one, submitted by Cyprus, Denmark, the Marshall Islands, Nigeria and the International Parcel Tankers Association (IPTA), proposes a tax on bunker fuels to be collected from bunker fuel suppliers or directly from owners. The revenue will be paid to an International Compensation Fund for Greenhouse Gas Emissions from Ships (ICF). IMO or UNFCCC will set a target for the sector, and for emissions above this target, the ICF will buy credits or support clean development in developing countries through CDM. The tax rate will therefore have to be set so that it covers all expenses. Any remaining funds will be used to further R&D efforts.

The proposal submitted by Japan is quite similar in setup, the only difference being that the revenue would be reimbursed to ships that meet or exceeds some benchmark set by IMO instead of buying credits. The Jamaican proposal suggests a tax on recorded fuel consumption rather than bunker fuels bought. This tax would be collected in port, and each ship would have to pay tax on fuel consumed on its voyage to that port. The revenue raised would be distributed as in the Japanese proposal.

The ICF is the one that have gained the most attention and support, so I will concentrate the analysis on this proposal.

The ICF is cost-efficient within the sector, as a uniform tax is levied on all use of bunker fuels. This allows ship owners and operators to individually assess which measure that is best for each vessel, be it technical or operational. As for cost efficiency across sectors, a sector-specific tax will perhaps not be entirely cost-efficient. But as the sector currently is under almost no regulation at all, a sector tax might still improve efficiency. In most Annex I countries at least,

industry and other modes of transport are already regulated, taxed and/or under some target system, raising their marginal abatement costs. This proposal might in fact rather alleviate a previous discrepancy rather than create cost-inefficiencies.

As for participation, it is worth reminding that any instrument enforced by the IMO probably will have to demand participation from its members. This "all or nothing" setting is part of why it has been so difficult to reach an agreement, but would be a major strength if any instrument is endorsed. The question is then of course, will this instrument be ratified by the member states? The suggestion that the funds raised will be used to support clean development in developing countries is probably the proposal with the most support, as this to some degree includes the differentiated responsibilities principle. The Jamaican proposal of differentiation with respect to routes is the only one that allows for a more substantial differentiating of responsibilities, opening up to the possibility of only taxing routes to and from Annex I countries.

A global tax on bunker fuels would be relatively easy to enforce. If it is levied on the suppliers, there would only be a limited number of suppliers to monitor. It can be envisaged that the agreement would include a credible punishment for suppliers evading tax enforced nationally. If the tax is imposed on the owners and operators alone, the Port State Control could demand to see receipts upon arrival at port. It has already been documented that the Port State Control has proven efficient in controlling, and it uses its right to detain ships in port.

The environmental effectiveness of the fund depends on the tax rate and the scope of the agreement. Since the price elasticity of fuel is quite low (Michaelowa and Krause 2000), it cannot be expected that the demand for fuel will be significantly reduced, especially now that fuel prices has dropped considerably. The environmental effectiveness of the agreement will therefore be determined by the tax rate indirectly, through the size and use of the fund.

If the tax is global, the carbon leakage within the sector would be very limited. But there could be carbon leakage if the tax causes a shift from the use of shipping to other means of transport. The price elasticity of demand for ocean-going shipping is generally low, but rises considerably if we look at short sea shipping (IMO 2009). This means that if a tax is levied on shipping alone, there will be some carbon leakage caused by the shift toward other modes of transport. This is

also a competitiveness issue, as short-sea shipping might lose to road and rail transport. The competitiveness is also challenged within the sector

5.5 Transferable permits: The METS

There have been three different Maritime Emission Trading System (METS) proposals discussed in IMO. The first one is submitted by Norway and set a sector-wide cap on emissions and includes trading mechanisms for both in-sector and out-of-sector reductions. The permits are to be auctioned and the revenue used for R&D. The proposal also opens for some exemptions on voyages to small island developing states.

The second, British, proposal differs in method of allocating the permits. Here, the permits are allocated to states for auctioning, thus allowing for a political distribution favoring developing nations. The third, French, proposal includes some more detail on the auctioning, but is otherwise similar to the Norwegian proposal. The main question is thus whether or not to allocate to states or have a global auction.

A global METS will probably be cost-efficient within the sector. If the system where to include out-of-sector trading, this would improve on the cost-efficiency across sectors. Either way, as with taxes, regulating the shipping sector might alleviate previous discrepancies rather than create new. A sectorial permits system can also be linked to other permits systems in the future, thus improving the cost-efficiency further. There is also no considerable market power that could influence the prices and there is no pre-existing tax regime that could cause distortions. There are however, considerable transaction costs for small companies. Parts of the sector consist of small firms with even smaller administrations, and they have voiced their concern over complicated permits systems (ICS 2014).

Grandfathered permits have shown to be politically feasible in several countries in recent years. This experience might induce other countries to participate. With the possibility of distributing permits to countries directly, one could make some concessions to developing countries,

ensuring their participation. However, the negotiations would likely be very difficult and grandfathered permits do not raise any revenue, diminishing the environmental effect.

Ensuring compliance with the METS would probably not face any other problems than a tax would. Buying the permits would be the owners and operators responsibility and the Port State Control would inspect.

The environmental effectiveness will depend on the stringency of the cap and the amount and use of raised revenue. Also, paradoxically, including emissions from shipping in a wider permits system might reduce the environmental effectiveness of the agreement. It is reasonable to assume that the marginal abatement cost of shipping is higher than the marginal abatement cost for land-based industry. If the two sectors are in the same permit system, the shipping sector would prefer to buy permits to abate, driving the price of permits up. The industry then has the choice between buying very expensive permits or very expensive abatement. Either way it puts an unfair burden of abatement on the industry, increasing marginal operational costs. The result could be too high prices for the industry and too low prices for shipping (Zetterberg 2008, Åhman 2008).

Additionally, much of the investment made in shipping is long-lived. That means that carbon-intensive investments made today will "lock" the sector to a more carbon-intensive path the coming decades. Inertia makes early abatement necessary in order to avoid that future abatement is even more costly. (Lecocq, Hourcade et al. 1998) concludes that in the face of uncertainty and inertia, it can be efficient to use additional effort to reduce investment in long-lived carbon-intensive capital stock over and above the price of permits. **********

A METS would cause the same carbon leakage and competitiveness issues as a tax would. If the permits system is global, there would be no evasion within the sector. Short-sea shipping would face tougher competition against other, more carbon-intensive modes of transport.

5.6 Comparisons

The prevailing trend in the economy in general seems to favor permits. A lot of permits system is being implemented in different countries and sectors. For maritime sector, it is possible to adjust

the agreement to include the differentiated responsibilities, by issuing extra permits to developing countries. There are however some concerns about transaction costs. Small firms in the industry itself strongly prefer taxes, because permit systems are more complicated and demand more administrational tasks from the owners and operators (ICS 2014). The theoretical evidence from section 4.3 also suggests that permits will not be as cost-effective as taxes for stock pollutants.

Many pre-existing conditions make maritime sector suited for an environmental tax. There already exist a robust institution that can oversee it, there is already rather thorough record-keeping on board, and it can be adjusted to only apply to certain routes. While this would limit the environmental effectiveness and raise the risk of carbon leakage and competitiveness issues for all the instruments, it might be necessary for there to be an agreement in the first place.

However, the price elasticity for energy intensity is very low. Previous price fluctuations in oil price have not had any long-term effect on bulk freight traffic apart from oil and coal. Other transport was somewhat influenced, but not more than what can be attributed to the decrease in demand of transported goods (Michaelowa and Krause 2000). This suggests that it is difficult to set a fuel tax high enough to change behavior without causing a modal shift toward road-, rail- and air transport. The main environmental effect from the tax would therefore be the use of the revenue, preferably on R&D and offsets (Anger, Faber et al. 2013). If better abatement technology is made available in the future, more in-sector abatement can be expected.

If however in-sector abatement is prioritized, either because of political considerations or because of the long life-span of new ships, command-and-control instruments can be necessary. When the investments are long-lived, carbon-intensive investments made today will "lock" the sector to a more carbon-intensive path the coming decades. Inertia makes early abatement necessary in order to avoid that future abatement is even more costly. Lecocq, Hourcade et al. (1998) concludes that in the face of uncertainty and inertia, it can be efficient to use additional effort to reduce investment in long-lived carbon-intensive capital stock over and above the price of carbon. The marginal cost of sufficient abatement at any one time exceeds any reasonable permit or carbon price, necessitating some initial large investments to set the sector on a better emission path. Command-and-control instruments might be necessary to ensure that the initial abatement is done, so that future abatement will be possible at a lower cost.

IMO has a long history of making regulation and given some time, the member countries have proven that they indeed can come to an agreement. Some standards can be implemented quickly, while others can only reasonably be applied to the production of new ships. Either way the expected cost can be assessed quite accurate by each firm, limiting uncertainty. So while command-and-control instruments cannot be the only instrument, it is a good way of ensuring that abatement efforts are started sooner rather than later.

6 Conclusions

The post-2012 climate architecture is yet to be agreed upon. Considering that few are optimistic about the prospects of an economy-wide IEA, sectorial agreements should be seriously considered as an important contribution to a larger framework. In order to better understand where and when they are suited, further studies are necessary. An area of particular interest for economists would be to make a theoretical model of a sectorial agreement as a supplement to an IEA. My contribution to the area has been a review of relevant literature and a discussion on the possibility of a sectorial agreement covering maritime sector. The main findings are listed below.

Firstly, sectorial agreement can be effective in ensuring larger participation among affected countries. This argument is supported by three effects: (1) By only looking at one sector, the differences in production technology become smaller than when comparing two economies. When asymmetry is reduced there is more common ground and easier to agree. (2) When making regulations for one sector only countries where this sector is sufficiently large are important. This means fewer participants overall. (3) There will be a higher cost-certainty when only looking at one sector, because the agreement has to be more specific. More certainty can possibly silence some national opposition to the agreement.

Secondly, sectorial agreements can include credible threats because trade restrictions can be imposed on specified goods produced in non-regulated countries. This may provide countries with the necessary incentive to join the agreement, because the cost of being on the outside is bigger than the cost of complying with the agreement. Alternatively, firms that provide services

in regulated countries can be given the opportunity to comply with the regulations, making the unregulated industries de-facto part of the agreement.

Thirdly, the theoretical evidence suggests that taxes are the most efficient instrument in a sectorial agreement. CO_2, the most important greenhouse gas, is a stock pollutant. That makes the yearly emissions of secondary importance and the marginal benefit curve of abatement relatively flat. This implies that taxes are more efficient. The fact that emissions from one sector in any case only would have a small impact on overall emissions strengthens this argument further. Additionally, s sector-wide permits scheme could lead to big fluctuations in the price of permits. This uncertainty could deter investments in new technology.

Lastly, when applying these findings on the case of maritime shipping, I found that a combination of taxes and command-and-control instruments should be implemented. Taxes because they are cost-efficient and command-and-control instruments to force the sector to make some in-sector abatement and adopt cleaner technology on ships that will be used for decades to come.

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